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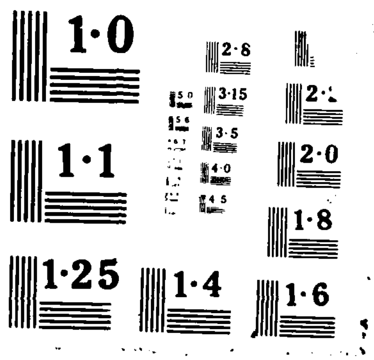
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## Major Accomplishments Under DAAG29-84-K-0045

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Under the auspicies of this grant, we have developed a hierarchical , combinatorial-Markov method for solving large reliability/ availability/ performance models of systems. The approach allows the modeler to combine good aspects of both combinatorial models and Markov models to obtain a cost-effective solution to large models. This research was instrumental in the design and implementation of a software package called SHARPE (Symbolic Hierarchical Automated Reliability and Performance Evaluator). This package is currently being installed at several Universities for educational purposes and several companies have expressed interest in using the package. Availability modeling of a VAX cluster system has been carried out jointly with Digital Equipment Corporation using SHARPE. SHARPE has also been used for the reliability analysis of large interconnection networks in the context of the Ph.D. thesis of LTCL Jim Blake.

Much of our research deals with the transient solution of large and stiff Markov and Markov reward models. We have developed a decomposition technique for the transient analysis of stiff Markov chains jointly with Dr. A. Bobbio of Institute Ferraris, Torino, Italy. A description of the technique was published in the IEEE Transactions on Computers (September 1986) and is receiving wide attention. We have carried out a thorough comparision of the transient analysis methods of Markov models within the scope of the Ph.D. thesis by Andrew Reibman. This work has received attention in Applied Probability and Operations Research community. Andrew has accepted a position at AT&T Bell Laboratories in order to further utilise this research in solving reliability models of communication systems.

Our work on Markov reward models is important not only because we have developed an efficient algorithm for numerical solution but also because of a large variety of applications we are exploring. The research on Markov reward models consists of interdisciplinary (with Dr. Kulkarni of Operational Research Curriculum at the University of North Carolina) and International (Dr. Francois Baccelli of INRIA, France and Dr. Raymond Marie of IRISA, Rennes, France) collaborations. The applications have addressed the effectiveness evaluation of $16 \times 16$ multiprocessor systems with various interconnection schemes, response-time distribution in an M/M/1 queue with processor sharing discipline, distribution of time-averages in queueing systems, and response time distributions of tasks in a system subject to failure and repair.

Another important area of research is in the analysis of the coverage of a fault tolerant system, that is, the probablity that the system can recover from a fault. We have studied a variety of models, from simple phase-type models to very complex stochastic Petri net models, and have investigated solution techniques for each model type. Our methodology allows consideration of external events that can interfere with recovery, such as a hard limit on recovery time, or the occurrence of a second near-coincident fault. We discovered that a policy of attempting transient recovery upon detection of an error (as opposed to automatically reconfiguring the affected component out of the system) may actually *increase* the unreliability of the system. This result holds if the error detectability is not nearly perfect, so that the risk of producing an undetectable error (if the transient error is present) is greater than the benefit gained by not discarding the component.

A list of all papers and thesis supported in part of by this grant is attached alongwith.

January 27, 1988

# Publications under US Army Grant DAAG29-84-K-0045

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